Single Battlefield Fuels (SBF) Made From Unconventional Resources

Material Issues – An Army Perspective

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Patsy A. Muzzell
Assured Fuels Team
TARDEC National Automotive Center

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Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

DOD Key Fuels and Specifications

Single Battlefield Fuel

Kerosene-type fuels

JP-8/F-34
- **MIL-DTL-83133**

JP-5/F-44
- **MIL-DTL-5624**

Jet A-1/F-35
- **ASTM D 1655 (U.S.)**
- **Defence Standard 91-91 (most ROW)**

Commercial & Other Military Fuel

Diesel fuels

No. 2-D and No. 1-D
- **A-A-52557 (CID*)**
  - **ASTM D 975**

F-76 (mil-spec marine distillate fuel)

*Commercial Item Description

End-uses in DoD fleets

CI engines designed to use diesel fuel

Army Tactical/Combat Vehicles and Equipment

- Tactical/combat vehicle fleets
- CE & MHE
- Other Equipment
  - Fuel storage, distribution, handling
  - Power generation
  - Future
- Army aircraft and watercraft

Wheeled Vehicles

HMMWV

FMTV

STRYKER

HEMTT

Tracked Vehicles

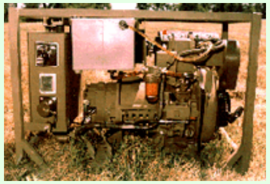
ABRAMS

BRADLEY

M113

Other

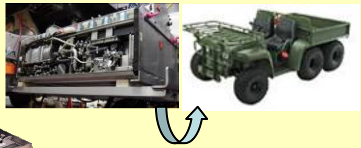
POWER PLANTS



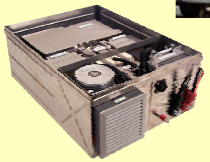
GENSETS

FORK LIFTS

Future Equipment



FUEL CELL APUs



HYDROCARBON REFORMERS

Construction & Materials Handling Equipment

CRANES / DOZERS / SCRAPERS / GRADERS

Introduction – Fuels of the Future

- Petroleum-derived fuels will be around for years, such as JP-8 (current SBF)

- However, non-petroleum derived fuels will increasingly make their way into the fuels supply, typically as blends
  - Semi-synthetic jet fuel (partly FT IPK*) used at Johannesburg International Airport
  - E-85 ethanol fuel, biodiesel fuel blends (B1 - B20)

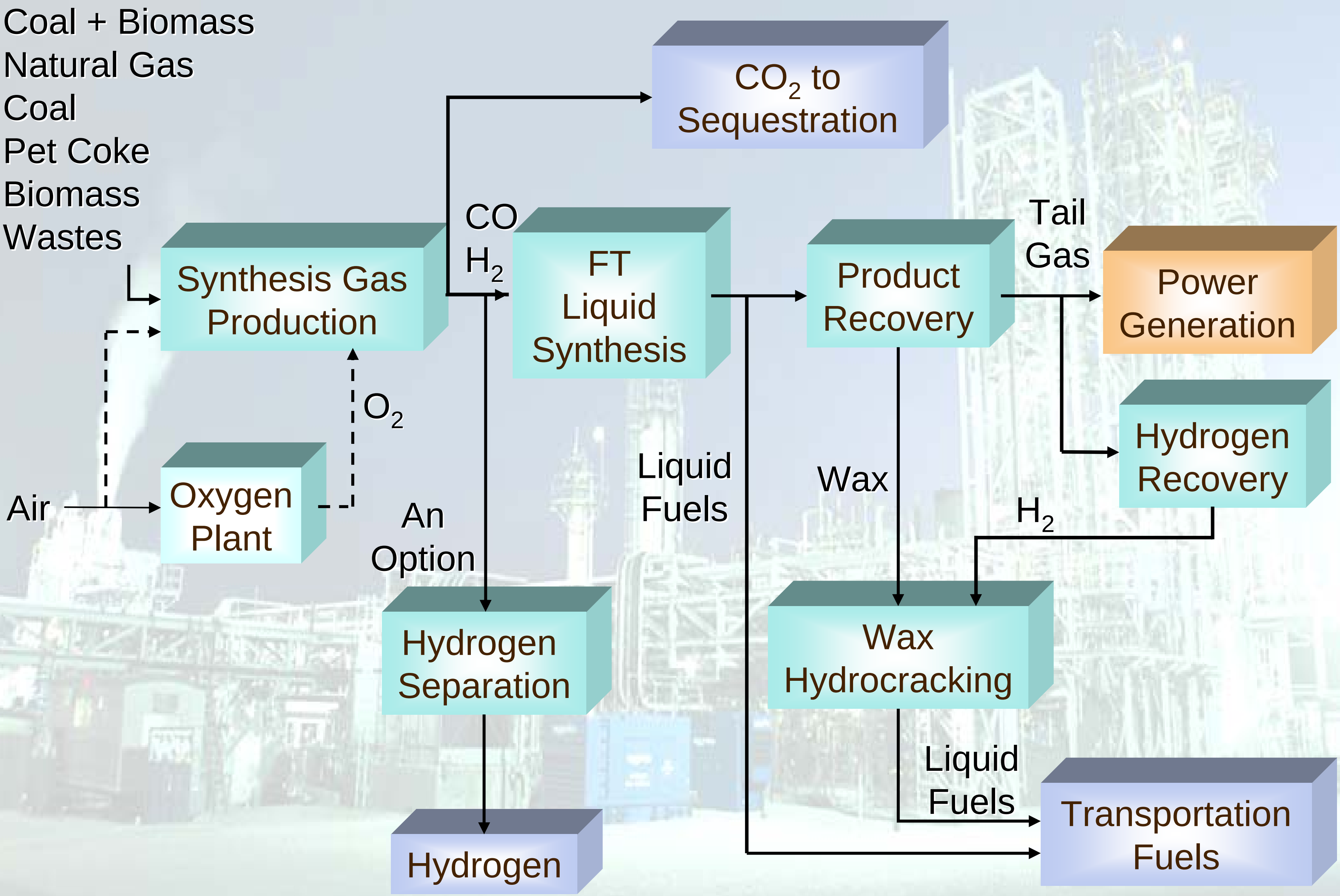
- Key reasons for blends (excluding energy policy drivers)
  - Limited volumes of unconventional fuels
  - May allow an otherwise unfit-for-use fuel to be used in exisiting equipment (or slightly-modified equipment)

* FT IPK is Iso-Paraffinic Kerosene – discussed in separate slide

Unconventional SBF on the Horizon

- Fischer-Tropsch (FT) derived
- BioJet
  - Synthesized from crop oils via thermal, and/or catalytic, and/or enzymatic processing [BioJet per DARPA BAA 06-43]
  - How compatible will this fuel be with existing equipment? Need samples for characterization of fuel – starting point to determining compatibility
- Other?

FISCHER-TROPSCH (FT) TECHNOLOGY



Fischer-Tropsch Derived Kerosene

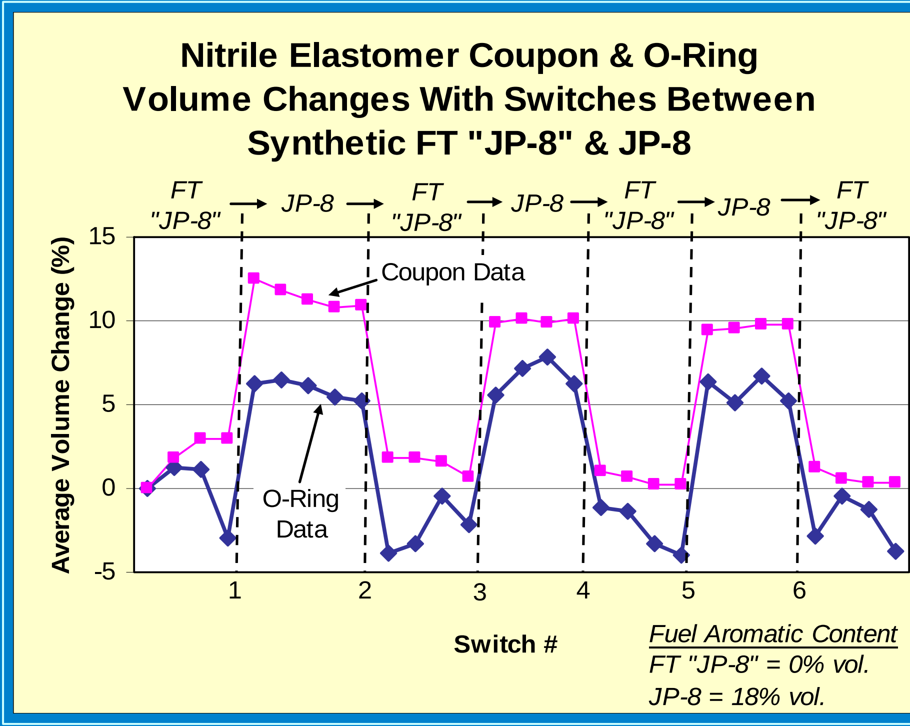
- FT synthesis step – product variations possible based on FT reaction parameters (catalyst, temperature, pressure, etc.)
  - Product typically contains only paraffins, mostly normal paraffins; many paraffins of long chain lengths (“waxy”)
  - Possible to produce product containing other species such as aromatics, olefins

- Upgrading step
  - Hydrocracking breaks up long chains into kerosene boiling range compounds
  - Hydroisomerization rearranges chains from n-paraffins to isoparaffins yielding kerosene meeting JP-8 freeze point requirement

- FT kerosene compositions meeting JP-8 freeze point requirement
  - FT Iso-Paraffinic Kerosene (FT IPK) – containing no aromatics
  - Possible to also produce FT-derived kerosene that containing aromatics

Fuel Leaks Possible From Sudden Switch to Lower Aromatic Content Fuel

- Some elastomers affected by change in fuel solvency (esp. aromatics in fuel)
  - Swelling: absorption of aromatic solute
  - Shrinkage: purging of aromatic solute
- Affected elastomers include Nitrile, common in Military fuel distribution system sealing applications
- Low aromatic fuels becoming more prevalent
  - Ultra-low sulfur diesel fuel
  - FT fuels
- Introducing lower aromatic fuels into existing equipment may result in some fuel leaks
- Mitigate risk of leaks through use of
  - Unaffected elastomers
  - Fuel blends

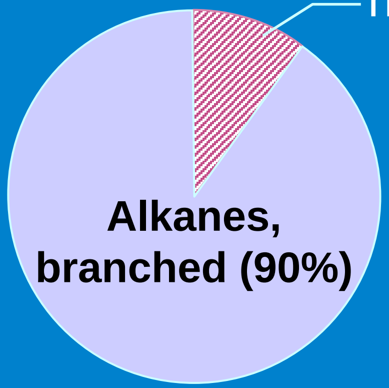


Data courtesy TARDEC Lab

SAE Paper No. 2007-01-1453, April 2007
"The Effect of Switch-Loading Fuels on Fuel-Wetted Elastomers "
(by TARDEC and SwRI™ authors)

FT Iso-Paraffinic Kerosene

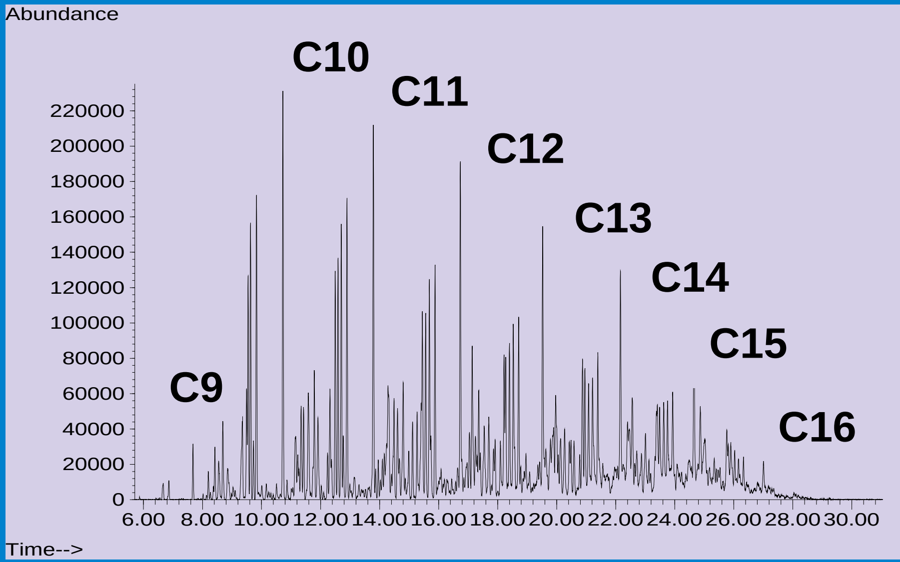
Hydrocarbon Types In FT IPK
(Iso-Paraffinic Kerosene)



Zero aromatics

Zero sulfur

No heteroatoms



FT IPK is paraffinic – contains mostly isoparaffins

whereas

Petroleum-derived fuels are rich in aromatics, cycloparaffins, and hetero-compounds

Some of these are polar compounds (N, O), typically trace amounts, responsible for much of a fuel's inherent lubricity

Fuel Lubricity Critical for Performance of Fuel-Lubricated Rotary Injection Pumps

- Some vehicles have fuel-lubricated fuel pumps
  - HMMWV (high density vehicle in Army ground vehicle fleet)
  - Some others (smaller populations in Army fleet)
- Test rig testing
  - HMMWV pump with hardened components: FT IPK lubricity appears adequately improved with use of Military approved lubricity improver
  - Other fuel-lubricated pumps (testing in progress-one common to Army and Navy)

HMMWV Rotary Injection Pump Test Results

Test	Pump	Duration (hours)	Pre-test (mm)	Post-test (mm)	Change (mm)	Lubricity additive (CI/LI) treat level in FT IPK
1	1	95.6	5.017*	5.113	0.096	None
	2	150.7	5.017	5.085	0.068	
2	3	500	5.017	5.024	0.007	12 (minimum treat level)
	4	500	5.017	5.011	-0.006	
3	5	500	5.017	5.022	0.005	22.5 (maximum treat level)
	6	500	5.017	5.019	0.002	

*= Roller-to-Roller Dimension Pump Assembly Specification is 5.017 cm ± 0.001 cm

Treated fuel tests run 500 hrs with minimal wear – indicative of acceptable field performance

Excessive wear occurred with untreated fuel

chipped roller shoe

Data courtesy of SwRI™

Concluding Remarks

- Fueling-up with unconventional SBF
  - Early use most likely in blends with petroleum fuel
    - Use of blends minimizes/eliminates fitness-for-use issues
    - Early acceptance by users critical when introducing new fuel
  - Strategic fueling flexibility would be enhanced by establishing the capability for freely interchangeable use of current SBF (JP-8) and unconventional SBF (not as a blended fuel)

- Determining fitness-for-use in existing equipment
  - Current SBF specifications evolved from history of use with petroleum-based fuels; are not performance-based specifications
  - An unconventional fuel may have properties meeting the chemical / physical property requirements found in these specifications, but not be fit-for-use